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RESEARCH MEMORANDUM

THE EFFECT OF CANOPY LOCATION ON THE AERODYNAMIC
CHARACTERISTICS OF A SWEPTBACK WING-BODY
CONFIGURATION AT TRANSONIC SPEEDS

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RESEARCH MEMORANDUM

THE EFFECT OF CANOPY LOCATION ON THE AERODYNAMIC
CHARACTERISTICS OF A SWEEPBACK WING-BODY
CONFIGURATION AT TRANSONIC SPEEDS

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SUMMARY

Aerodynamic data have been obtained for a 45° sweptback wing-body-canopy configuration at transonic speeds with the canopy placed on the body so that the cross-sectional area of the canopy approximately filled the concave portion of the basic wing-body cross-sectional-area distribution curve (design location) and with the canopy placed 0.0614 of the body length forward of the design location. Data have also been obtained for the basic wing-body combination.

Placing the canopy in the rear position significantly reduced the drag of the configuration at transonic speeds, increased the lift, and did not appreciably affect the slope of the pitching-moment curve.

INTRODUCTION

An aerodynamic concept now called the transonic area rule was presented in reference 1. This concept stated that "near the speed of sound the zero-lift drag rise of a wing-body configuration generally should be primarily dependent on the axial distribution of the cross-sectional areas normal to the airstream." It has been shown, reference 2, that the drag of a wing-body combination could be reduced by application of the transonic area rule at transonic speeds up to moderate lift coefficients. On the basis of this concept, it has been reasoned that in the transonic speed range a canopy placed on a wing-body configuration such that the axial distribution of cross-sectional area is improved would add less drag than one placed such that the area distribution is adversely affected. Conceivably, the drag of the wing-body-canopy configuration with a properly located canopy might even be less than the drag of the original wing-body configuration.

This paper presents the results of a force-test investigation of a sweptback wing-body-canopy configuration with the canopy placed longitudinally so as to fill most smoothly the concave portion of the area distribution curve of the wing-body combination near the leading edge of the wing root, and with the canopy placed 0.0614 of the body length forward of the original design location. The forward position would provide improved visibility. The canopy size was such that the wing-canopy configuration may be considered as approximately a 0.05-scale model of a fighter-type aircraft. The angle-of-attack range of the tests was 0° to 8° . The Mach number range was 0.80 to 1.15, and the Reynolds number range was 3.9×10^6 to 4.1×10^6 .

APPARATUS AND MEASUREMENTS

Tunnel

The investigation was performed in the Langley 8-foot transonic tunnel which has a dodecagonal slotted test section and is capable of continuously variable operation through the speed range up to a Mach number of approximately 1.15. Detailed discussions of the design and calibration of this tunnel have been presented in references 3 and 4. The uniformity of the Mach number distribution in the model region is within ± 0.006 . Tunnel-wall constraint and blockage corrections have not been applied to the data because such corrections are negligible. The data are insignificantly affected by shock reflection at the Mach numbers for which data are presented.

Models

The pertinent dimensions of the models have been presented in figure 1. A photograph of the model with the canopy mounted in the rear position has been presented as figure 2. The cross-sectional area of the canopy in the rear or design position approximately fills in the concave portion of the area distribution for the wing-body combination near the wing-leading edge. The cross-sectional area with the canopy in the forward position (0.0614 of the body length forward of the design position) has a concave area distribution although the original concave portion is somewhat relieved. The profile of the canopy behind the windshield consists of the back part of an NACA 65A-series airfoil with the camber line coincident with the top body meridian. The cross sections consist of semicircles "sheared" so that the horizontal diameter of the canopy becomes coincident with the body circumference. A more complete description of this "shearing" has been presented in reference 5.

Angle-of-Attack Measurements

The angle of attack was measured by an electrical strain-gage pendulum device mounted internally near the base of the support sting. Sting and model deflections occurring ahead of this point, due to forces and moments acting on the model, were determined from static tests. These corrections were applied to the angle of attack. The maximum correction for deflection due to load was approximately 0.6° . The angle of attack was also corrected for the approximately 0.1° upflow existing in the Langley 8-foot transonic tunnel. The errors of the absolute value of the angle-of-attack measurements have been estimated to be less than 0.1° . The incremental angle errors are considerably less than this amount.

Lift, Drag, and Pitching-Moment Measurements

The normal force, axial force, and pitching moment about the quarter chord of the mean aerodynamic chord for the models were measured by an internally mounted electrical strain-gage force balance. The pressures at the base of the model (fig. 3) were measured and the axial force was adjusted to the condition of free-stream pressure at the model base. These forces were resolved along the wind axes for presentation in this paper. An estimate of the maximum errors in the repeatability of the data reported herein is presented in the following table:

	Error at -	
	Subsonic speeds	Supersonic speeds
Lift coefficient, C_L . . .	± 0.008	± 0.004
Pitching-moment coefficient, C_m	± 0.005	± 0.003
Drag coefficient, C_D . . .	± 0.001	± 0.0005

The errors are usually less than these maximum values.

RESULTS AND DISCUSSION

Lift

The lift coefficient as a function of the angle of attack has been presented in figure 4 for the three configurations tested. Addition of the rear canopy to the basic wing-body combination slightly increased

the lift-curve slope between Mach numbers of 0.96 to 1.03 inclusive and addition of either of the canopies increased the lift coefficient at an angle of attack of 0° . The lift, at a given angle of attack, for either canopy configuration was larger than the lift for the basic wing-body configuration, and the lift for the rear-canopy configuration was usually larger than that for the forward-canopy configuration at supersonic velocities. This lift increase is probably caused by the induced velocities over the canopy which may in turn have created a lower pressure field over the upper surface of the forward portions of the wing. This phenomenon is similar to that observed for modification A of reference 6.

Pitching Moment

The pitching-moment coefficients about the quarter chord of the mean aerodynamic chord have been presented as a function of the lift coefficient, for the three configurations tested, in figure 5. Addition of either canopy did not significantly alter the slopes of the pitching-moment curves. The rear canopy caused a positive increment in the pitching moment at all Mach numbers throughout the entire lift range investigated. The forward canopy caused a similar increment mainly at supersonic speeds. Although the canopies did not appreciably affect the slope of the pitching-moment curves the observed increment of pitching moment due to the canopies is indicative of forward center-of-pressure shifts.

Drag

The basic drag data have been presented in figure 6 as a plot of drag coefficient as a function of lift coefficient for the three configurations tested. The variation of drag coefficient with Mach number has been presented in figure 7. The maximum lift-drag ratio characteristics have been determined from figure 6 and presented in figure 8.

Addition of the canopy in the rear position significantly reduced the drag of the configuration at a given lift coefficient through the entire lift range investigated at Mach numbers above 0.93 (fig. 7). It should be noted that the drag of the configuration with the canopy in the forward position was lower than the drag for the rear-canopy configuration at high lift and Mach number conditions (at $C_L = 0.4$ above $M \approx 1.10$ and at $C_L = 0.5$ above $M \approx 1.07$).

The drag reductions noted due to the canopy at angles of attack larger than 2° are similar to the drag effects found for modification A, of reference 6, and are associated with the increase of lift due to the canopy. It may be noted (figs. 4 and 6) that the drag at a given angle of attack above 2° is often largest for the rear-canopy configuration

although the drag at a given lift coefficient is lowest. At $\alpha = 0^\circ$, however, the drag interference was such that the drag increment of the rear canopy was negative at Mach numbers above 0.96.

Although the drag of the rear-canopy configuration was lower at sonic speed than either the forward-canopy configuration or the basic wing-body configuration, the Mach number at which the drag rise began was not much different for any of the configurations tested (fig. 7).

The maximum lift-drag ratio near sonic velocities for the rear-canopy configuration is somewhat larger than that for the basic wing-body configuration or the forward-canopy configuration (fig. 8). The lift coefficient for maximum lift-drag ratio was higher for either canopy configuration than for the basic wing-body configuration at subsonic Mach numbers above 0.93 but was lower at supersonic Mach numbers.

An estimate of the transonic drag rise for the three configurations tested was made by the method of reference 7. The transonic drag-rise coefficient estimated for the wing-body combination was approximately one-half of that measured. However, the drag increments due to either canopy location estimated by the method of reference 7 were in substantial agreement with the measured increments.

CONCLUSIONS

Aerodynamic data have been obtained for a 45° sweptback wing-body-canopy configuration with the canopy mounted on the body so as to fill partially the concave portion of the wing-body configuration cross-sectional-area distribution near the wing leading edge and with the canopy placed 0.0614 of the body length forward of this original design location. Data have also been obtained for the basic wing-body configuration. Analysis of the data obtained indicated the following conclusions:

1. The drag was reduced at Mach numbers above 0.93 when the rear canopy was added to the basic wing-body configuration.
2. When the canopy was moved forward in an attempt to improve the visibility, the drag was increased over most of the lift range at Mach numbers above 0.93. However, the drag was reduced at high lift and Mach number conditions (at $C_L = 0.4$ above $M \approx 1.10$ and at $C_L = 0.5$ above $M \approx 1.07$).
3. The lift, at a given angle of attack, for either canopy configuration was larger than the lift for the basic wing-body configuration

through the entire range investigated, and the lift was usually larger for the rear-canopy configuration than for the forward-canopy configuration at supersonic Mach numbers.

4. The addition of the canopy in either position did not change the slopes of the pitching-moment curves.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., May 5, 1954.

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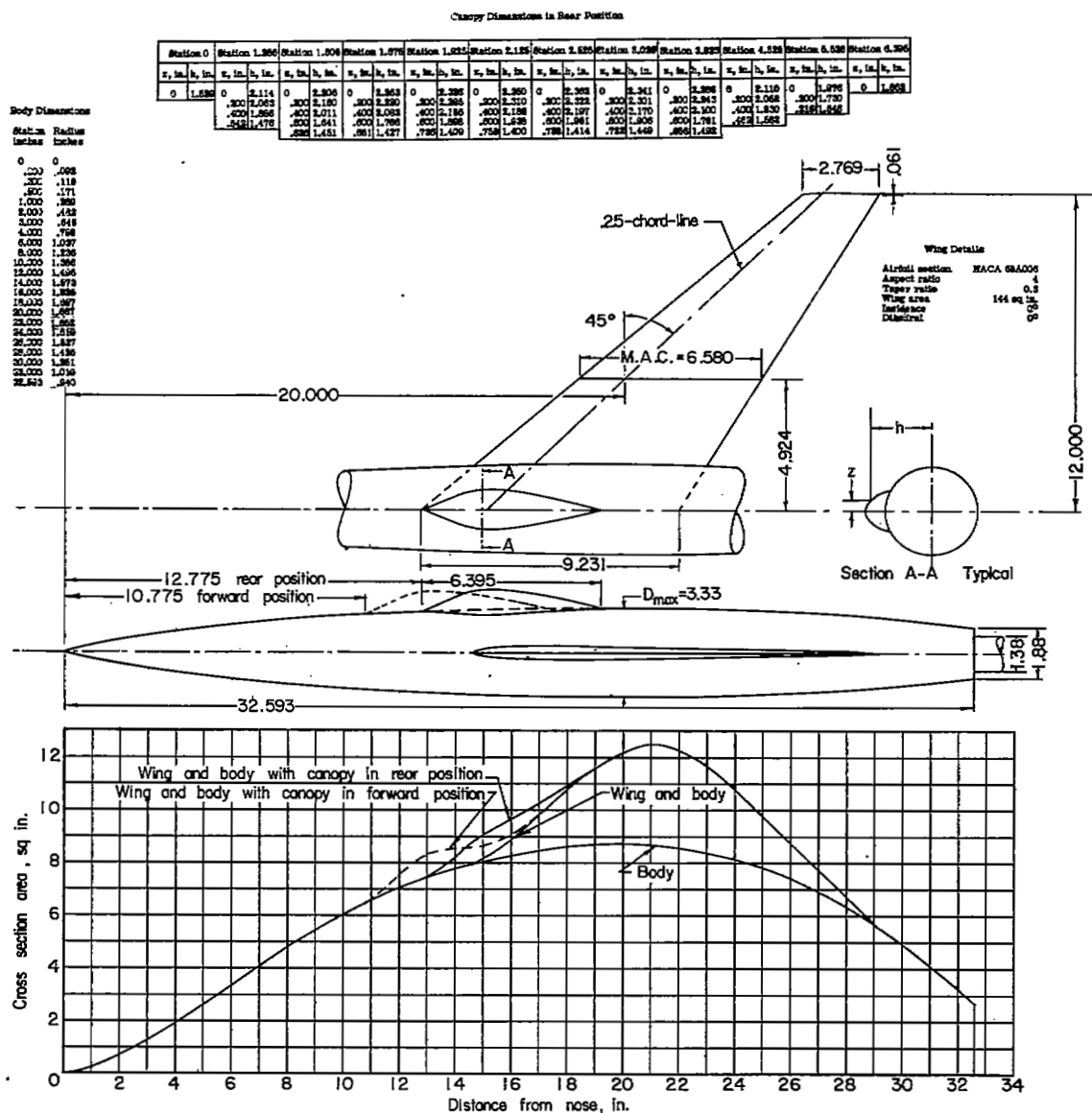
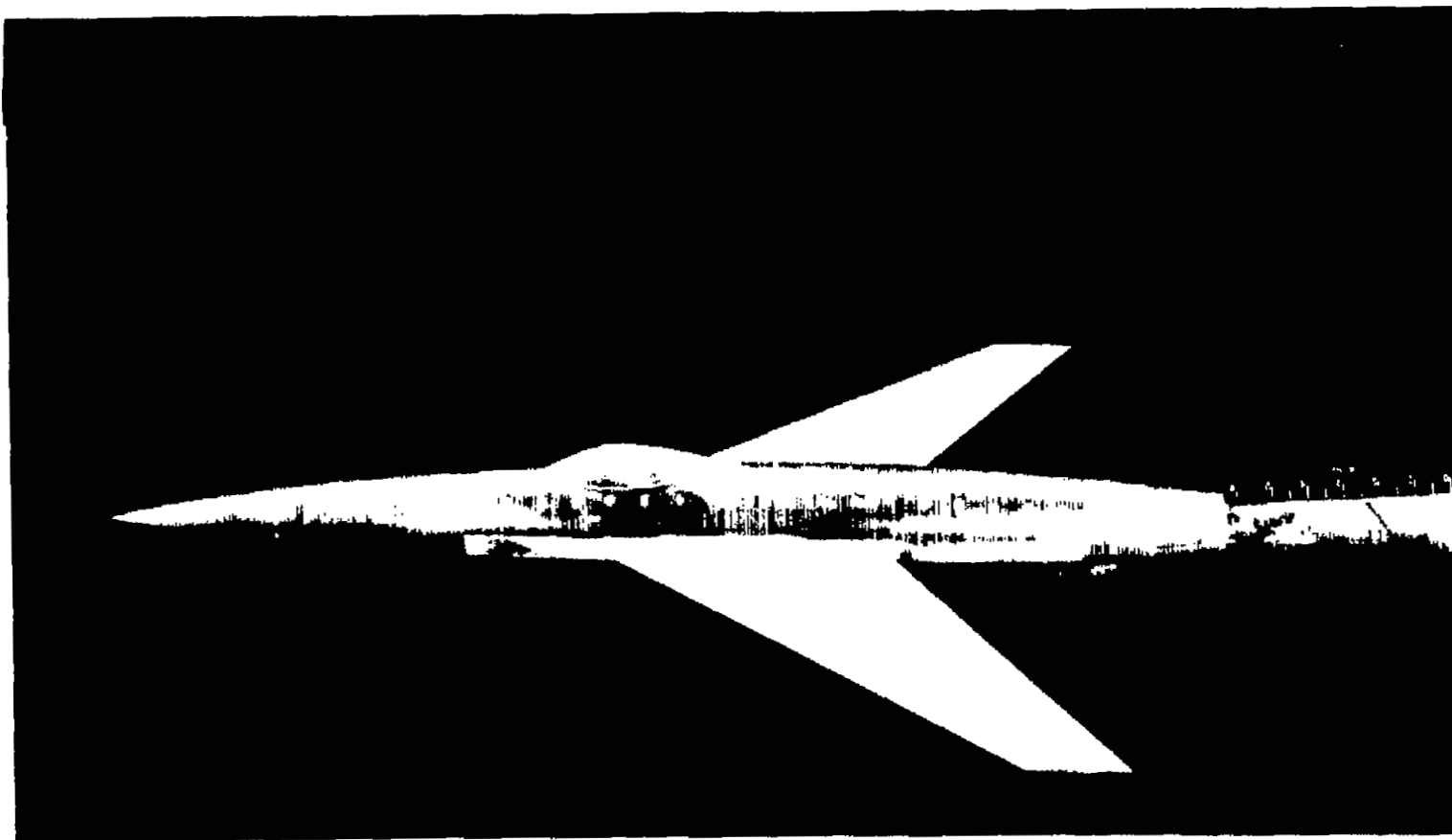


Figure 1.- Model details. All dimensions are in inches.



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Figure 2.- Photograph of model with the canopy in rearward position.

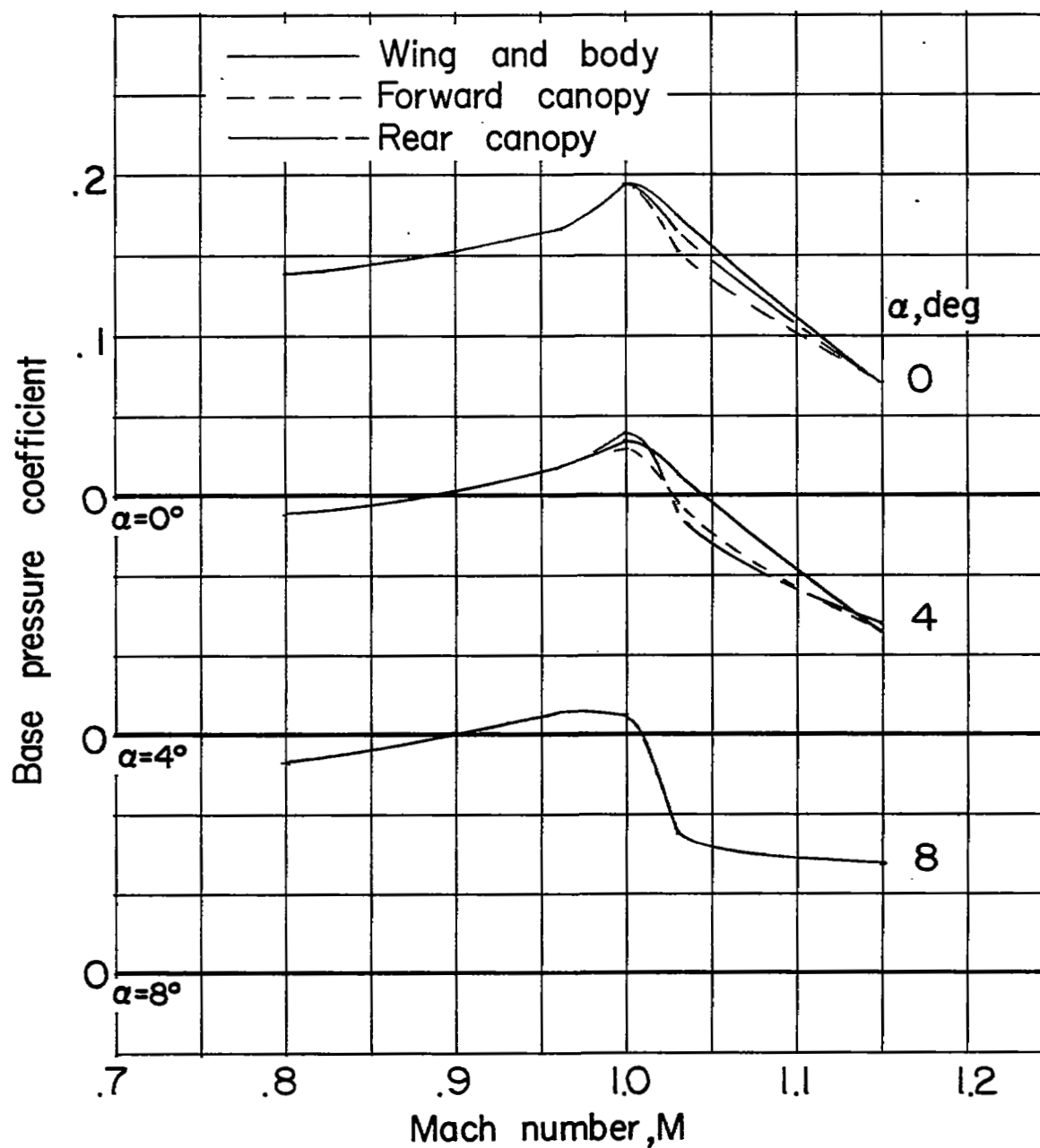


Figure 3.- Variation with Mach number of the base pressure coefficient for the sting-mounted model.

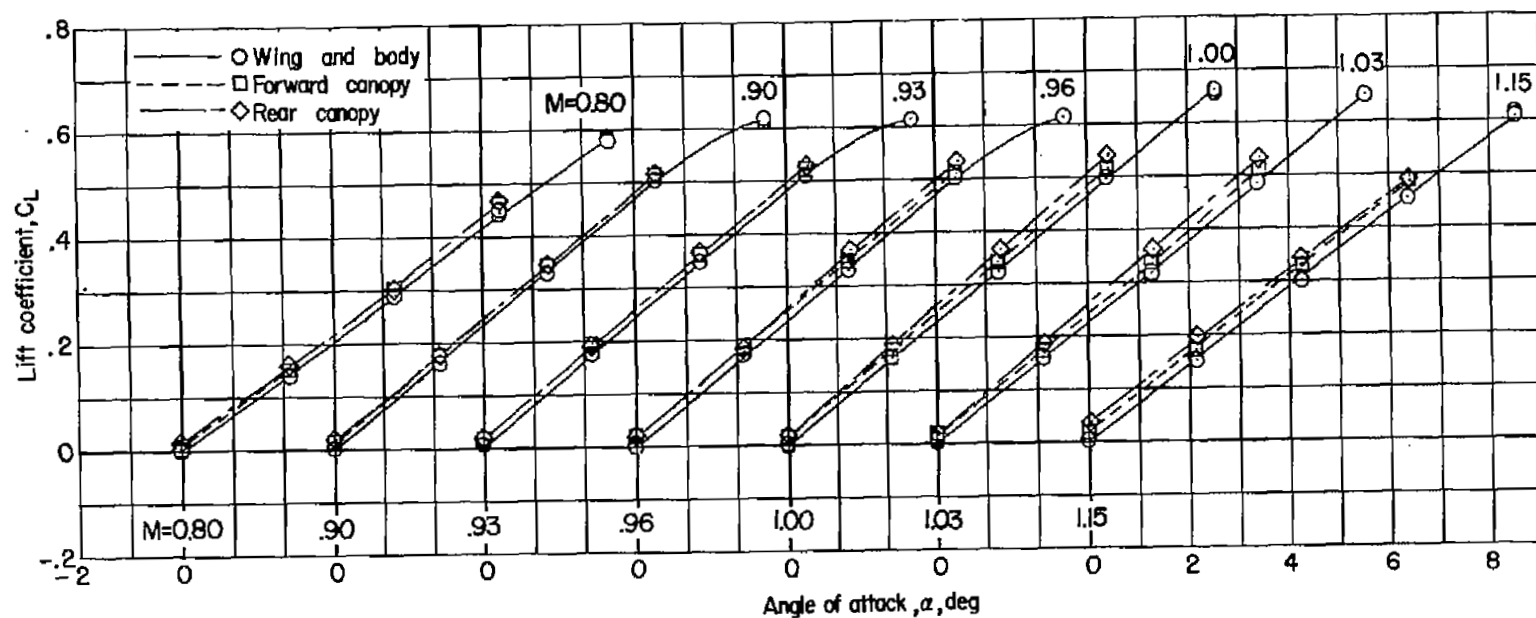


Figure 4.- Variation of lift coefficient with angle of attack.

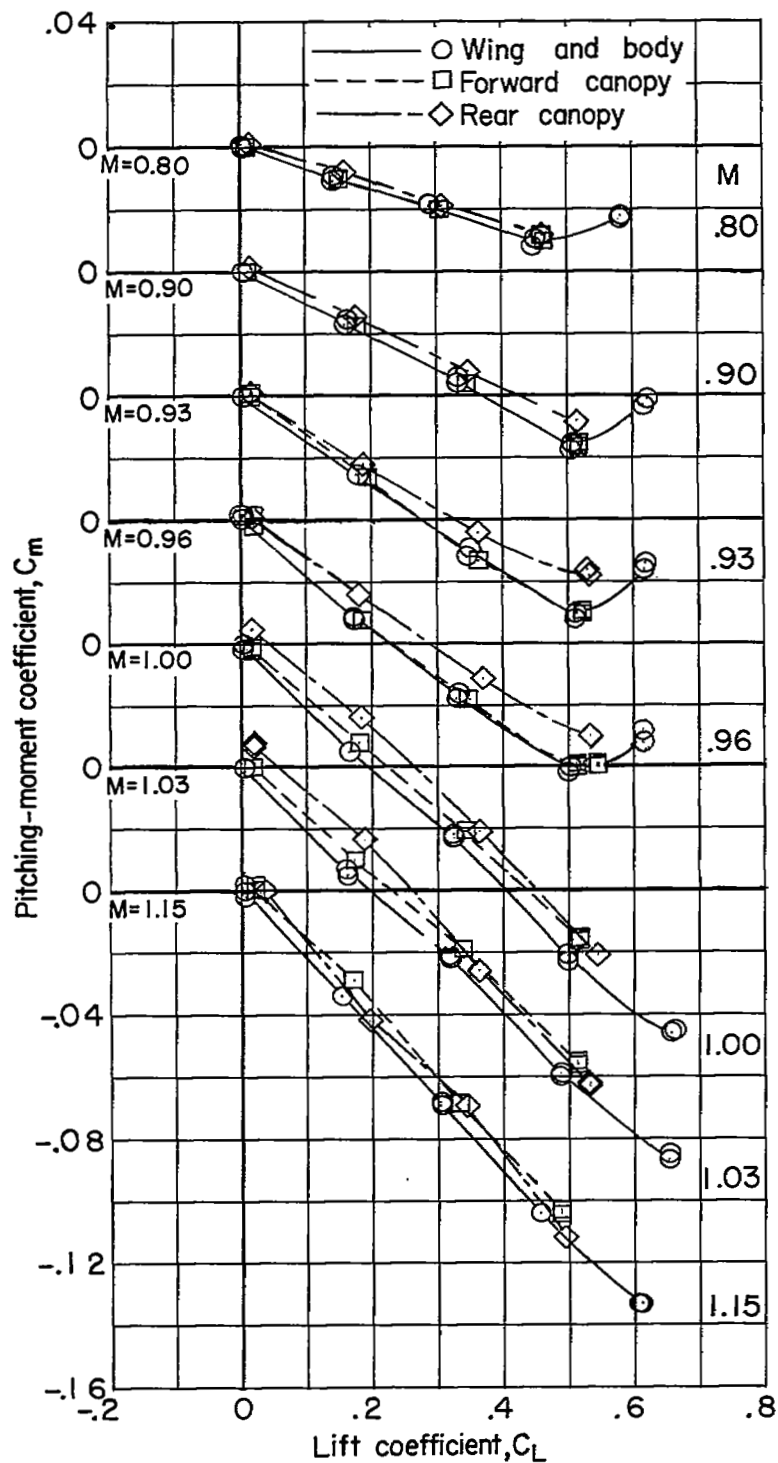


Figure 5.- Variation of pitching-moment coefficient with lift coefficient.

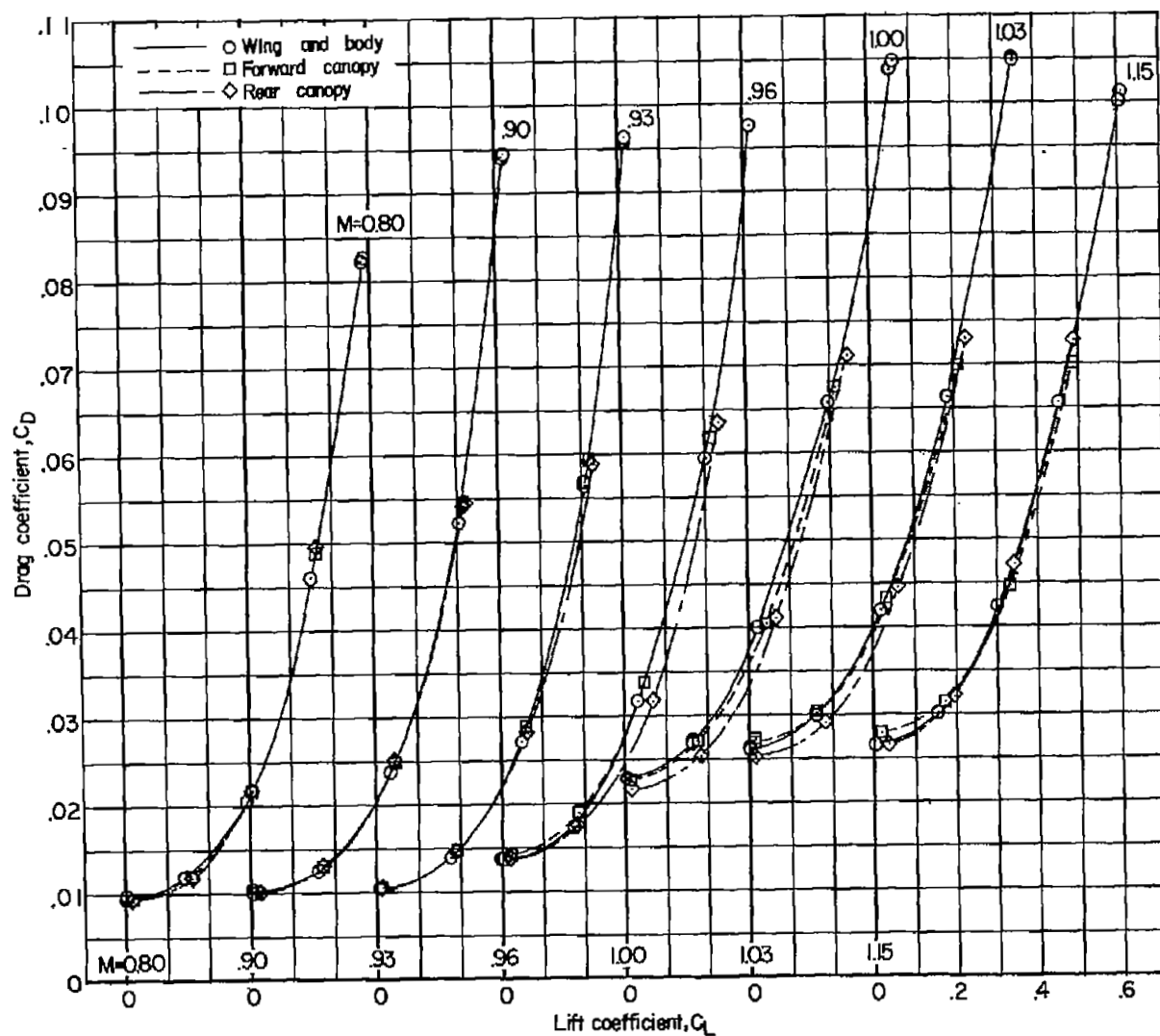


Figure 6.- Variation of drag coefficient with lift coefficient.

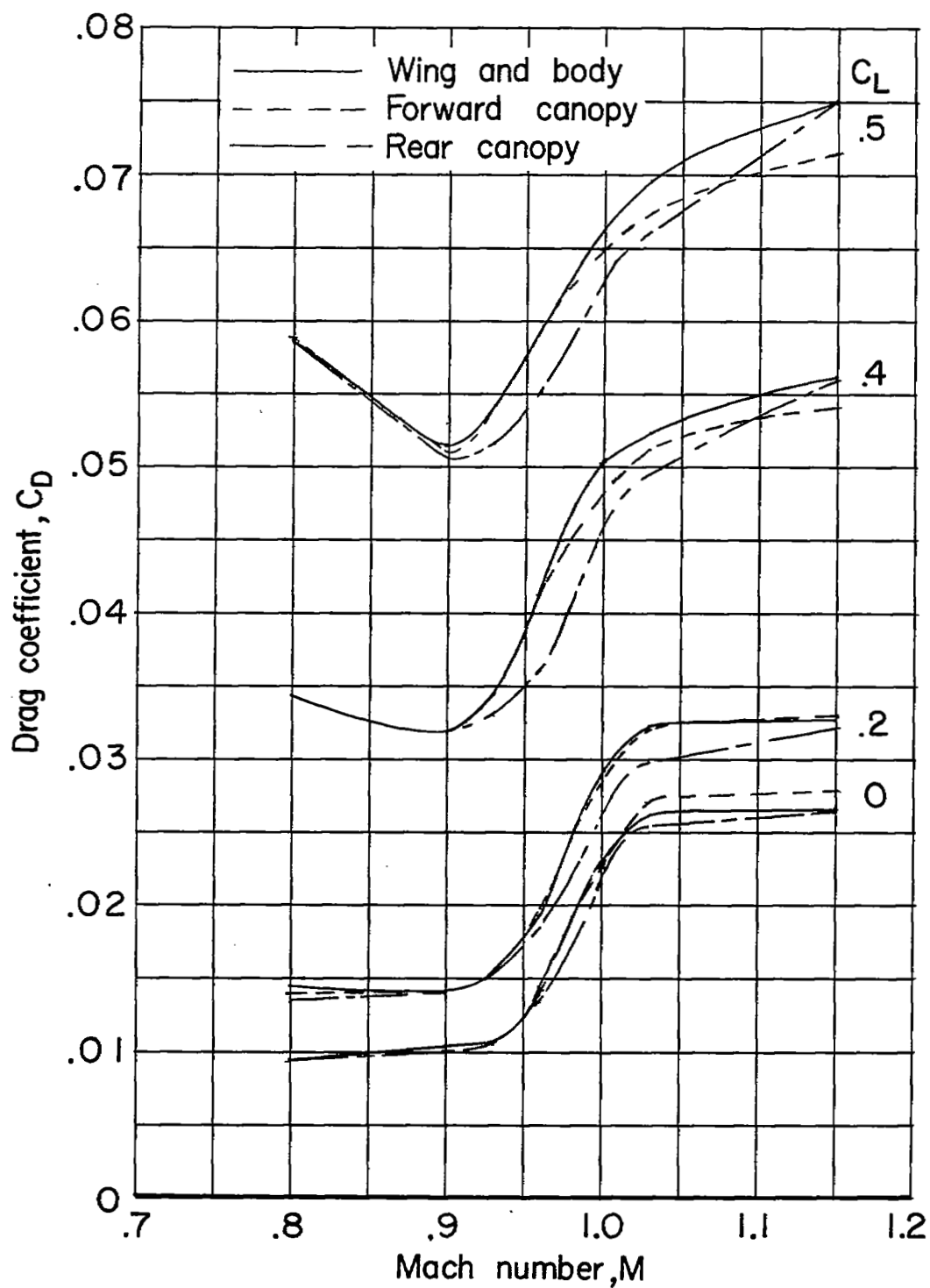


Figure 7.- Variation of drag coefficient with Mach number.

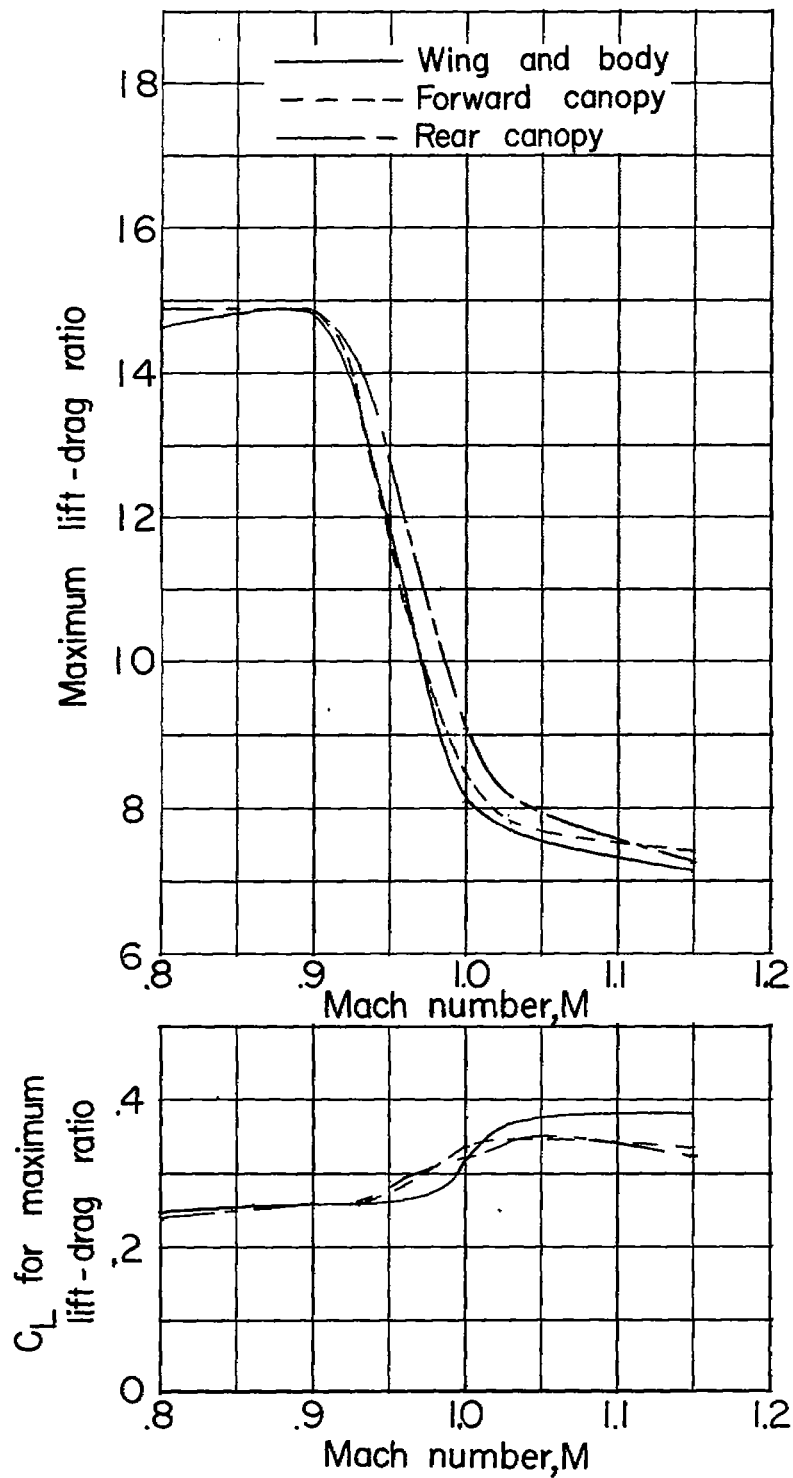


Figure 8.- Maximum lift-drag ratio characteristics.



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